UNIVERSITÀ DEGLI STUDI DI NAPOLI
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DOMESTIC VERSUS INTERNATIONAL R&D SPILLOVERS AND PRODUCTIVITY PERFORMANCE OF LARGE INTERNATIONAL FIRMS

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Michele Cincera* and Luigi Aldieri**

Abstract
The objective of this paper is to further investigate the findings obtained by Capron and Cincera (1998) as regards the effects of both national and international stocks of R&D spillovers on firms productivity growth. The analysis is based on the same data set as Capron and Cincera (1998) which consists of a representative sample composed of 625 worldwide R&D-intensive manufacturing firms over the period 1987-1994. Additional results based on the recent System Generalised Method of Moments (GMM) estimator proposed by Arellano and Bover (1995) are presented. The empirical findings indicate that spillover effects significantly influence firm's productivity. In particular, results based on the system GMM estimator shows that the United States are mainly sensitive to their national spillover's stock while Japan and Europe appear to mainly draw from the international stock.

Keywords: national and international R&D spillovers, system GMM panel data estimator, total factor productivity growth.

JEL codes: O33, O47

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1. INTRODUCTION

Knowledge accumulation and its progress have been for a long time recognised as one of the central tenets of economic growth (Jones, 2002). It is also widely acknowledged that creative and absorptive capacities explain substantial part of income differentials within and across countries (OECD, 1996). Furthermore, because of their partially non-excludable as well as non-rival peculiar characteristics, new knowledge goods do not provide positive effects only on the productivity of the single firm which produces and accumulates them, but investments in such activities also add to the global pool of knowledge. Thus, the R&D and innovative efforts of a given knowledge creator may be accompanied by external effects on other economic agents' innovative efforts and economic performance. As underlined by the endogenous growth literature, the role played by R&D externalities as a privileged mechanism of linkages across economic agents are both national and international in scope[1].

An important aspect of R&D spillovers in relation to economic growth is indeed the relative extent of the national spillover stock compared to the international one. If these effects are essentially national in scope where the knowledge creation effort is taking place then the economic growth rate in each country will be essentially determined by the country's own total R&D stock. At the other end, if R&D spillovers are purely international in scope then the national growth is mainly determined by the innovative efforts carried out by firms located abroad. Empirical studies in general confirm the existence of spillovers within and across industries within a country (Griliches, 1992; Van Meijl, 1995). However, recent empirical evidence indicates that the major source of knowledge progress leading to productivity growth in these countries is not national but rather international (Coe and Helpman, 1995; Eaton and Kortum, 1999; Keller, 2002). This suggests that countries with stronger linkages with those countries that are on the technological frontier would be the net winners in terms of total factor productivity performance.

The main goal of this study is to analyse the relative role of both national and international R&D spillovers on firms' productivity performance. The traditional framework implemented relies on the assumption that knowledge externalities are realised in two steps. Knowledge flows represent the first step and take place whenever ideas generated by a firm or country are learned by another firm or country. Such a learning process creates a pool of accessible external knowledge, which in turn has a positive impact on productivity (second step). The pool of external knowledge is usually measured as the amount of R&D conducted elsewhere weighted by some measure of proximity in the technological or geographical space. These weights are assumed to be representative of the intensity of knowledge flows between the source and the recipient of R&D spillovers. Different proximity measures have been proposed in the literature[2]. The one implemented in this study rests on the methodological framework developed by Jaffe (1986) and also implemented by Capron and Cincera (1998). This framework consists in locating firms into a technological space, the idea being that the closer two firms are in such a space, the more the R&D and the economic performance of one firm is supposed to benefit from the spillovers generated by the R&D of the second firm. As in Jaffe (1986), the total R&D spillover variable is split into two components, a local and an external one. The local component refers to externalities arising from firms operating in narrowly defined technological fields of specialisation. In addition, given the international dimension of the data set, a further distinction is operated between the national and the international component of this variable.

[1] See Cincera and van Potttelsberghe (2001) for a recent review on international R&D spillovers.
[2] See Mohnen (1996) and Cincera (2004) for a review.

The paper is organised as follow. Section 2 presents the data set, the specifications relating productivity to the spillover variables as well as the implemented econometric framework. Section 3 reports the main empirical findings. First, basic results are provided on the relationship between firms' output and the total pool of R&D spillovers and second estimates regarding its different components, i.e. local, external, national and international are discussed. Section 4 concludes.

2. DATA, PRODUCTIVITY EQUATIONS AND ECONOMETRIC FRAMEWORK

2.1. Data set

In this paper, we use the Large International Technology Enterprises (LITE) database[3]. The main characteristic of this database is its international dimension. The core of the database consists of an unbalanced panel of 2676 worldwide manufacturing firms that have reported positive R&D expenditures over the period 1980 to 1995. Besides R&D expenses, information has been collected on variables such as European patent applications by technological fields, net sales, the number of employees, capital expenditures, raw material expenses and sales by geographic segments. The empirical analysis performed in this study is based on a sub-sample extracted from the LITE database. This sub-sample is the same as in Capron and Cincera (1998). Tables 2.1 and 2.2 show the representativeness of firms in their national economies in terms of net sales and R&D. It follows that the representativeness of these variables is low in the early 'eighties' and more important in some countries, e.g. the four largest economies in the European Union, Japan and the United States.

2.2. Productivity equations

The R&D activity carried out by firms is expected to stimulate their productivity. Besides the impact of the firm's own R&D capital as well as the influence of labour and of the physical capital stock on productivity, it is worth examining to what extent the spillover stocks improve the firm's productivity. In order to investigate this question, an extended Cobb-Douglas production function is used (Griliches, 1979). Formally, we have:

$$\ln S_{it} = \alpha_i + \lambda_t + \beta_1 \ln C_{it} + \beta_2 \ln K_{it} + \beta_3 \ln L_{it} + \gamma \ln X_{it} + \varepsilon_{it} \qquad (1)$$

where: ln is the natural logarithm,
L_{it} is the employment of firm i at time t (i = 1 to 625, t = 1 to 8),
K_{it} is the stock of R&D capital,
S_{it} is the net sales,
C_{it} is the stock of physical capital,
α_i is the firm's specific effect,
λ_t is a set of time dummies,
X_{it} is a vector of spillover components,
γ is its associated vector of parameters,
ε_{it} is the disturbance term.

[3] See Cincera (1998) for more information about the construction of this data set as well as to learn more about the variables considered.

Table 2.1. Representativeness of the LITE database: Net sales as percent of GDP

Year / Country	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Australia	0.1	0.7	0.6	0.8	11.8	13.2	13.8	14.7	15.6	17.6	17.8	16.5	16.9	16.8
Austria	0.5	0.7	4.9	4.7	10.6	7.3	10.1	7.7	7.1	8.6	6.9	7.0	6.4	5.2
Belgium	0.0	0.0	0.0	0.0	5.7	5.3	5.2	5.6	5.5	5.1	4.8	4.6	4.3	4.2
Canada	3.1	3.2	3.0	2.5	11.4	10.4	10.5	9.5	8.9	9.1	8.6	8.9	9.0	9.7
Denmark	1.6	1.8	1.8	2.2	5.2	5.0	4.8	5.1	4.6	5.9	5.9	6.0	6.0	5.3
Finland	4.6	5.0	5.2	6.1	44.5	42.6	43.1	44.4	46.4	47.1	46.5	52.5	57.7	53.6
France	1.8	1.5	2.5	8.4	24.3	21.9	23.9	25.9	28.5	27.5	28.1	27.0	25.3	19.1
Germany	1.0	1.5	1.7	8.0	36.6	32.8	32.3	33.8	34.6	33.1	30.4	28.5	26.6	21.5
Greece	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.3	0.4	0.4	0.5	1.0
Ireland	0.0	0.2	0.2	1.6	7.5	7.8	8.9	10.5	12.1	13.3	11.5	12.3	12.9	12.2
Italy	0.2	0.3	0.4	4.6	5.0	5.1	7.7	9.0	9.4	12.8	12.0	11.9	11.8	1.0
Japan	0.1	0.2	0.2	0.3	28.0	30.0	26.2	27.3	30.2	32.1	34.1	34.5	33.5	31.9
Netherlands	1.3	1.5	1.5	2.2	81.0	57.9	54.8	55.2	58.9	57.2	55.6	51.5	51.4	49.6
Norway	2.5	2.6	2.7	3.9	25.3	27.6	27.3	25.7	26.9	27.3	27.4	26.7	26.9	27.0
Spain	2.9	2.6	2.7	2.9	2.3	1.9	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Sweden	2.6	5.8	5.8	5.9	35.5	34.6	35.9	36.3	36.0	32.0	27.9	28.9	35.2	40.4
Switzerland	0.3	0.3	0.3	0.7	44.6	38.3	38.3	41.6	45.1	40.9	41.6	43.8	45.0	41.6
UK	2.2	3.7	3.8	6.5	46.4	47.1	46.9	47.7	51.3	50.6	47.3	45.0	46.1	43.5
USA	4.9	4.7	4.7	5.3	35.0	32.5	32.8	33.8	33.1	34.1	32.7	32.0	31.5	31.4

Source: Cincera (1998).

Table 2.2. Representativeness of the LITE database: R&D in % of total domestic R&D expenditures

Year / Country	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Australia	0.0			0.0		1.5	4.5	5.9		8.6				
Austria	0.0	0.0	0.0	0.0	5.0	4.7	4.7	3.7	4.4	6.1	6.4	9.5	7.6	7.5
Belgium			0.0	0.0	10.9	11.5	11.8	13.2	13.0		11.4			
Canada	2.1	2.1	0.6	0.6	14.5	15.5	18.6	17.0	16.7	20.7	19.2	20.4	20.4	23.1
Denmark	0.0	2.3	2.6	3.2	12.3	11.3	11.0	12.5	13.5	15.9	15.9			
Finland	0.0		3.4	5.9	31.3	31.3	36.8	40.7	40.2	37.7	33.3	37.6	43.0	
France	0.2	0.6	0.9	18.4	45.3	43.2	40.6	40.8	38.6	36.4	44.9	44.3	42.6	
Germany	0.2	1.1	2.1	6.8	42.7	43.3	46.0	55.5	58.0	65.4	53.4	60.5	56.5	
Greece	0.0	0.0	0.0	0.0	0.0	0.0		0.3	1.6		1.8			
Ireland	0.0	0.0	0.0	0.0	0.3	1.7	2.7	3.0	5.5	5.4	5.7	6.7		
Italy	1.2	2.0	2.3	16.9	15.6	16.2	20.8	27.5	27.8	35.6	33.9	27.7	28.4	2.8
Japan	0.2	0.2	0.2	0.3	22.7	29.9	28.1	30.0	33.0	33.9	36.7	39.4	40.0	
Netherlands	0.2	0.2	0.2	0.9	70.9	66.2	64.5	73.9	84.7	82.0	78.4	74.9		
Norway	1.8	2.2	5.3	8.1	16.4		20.1		21.4		22.1		26.7	
Spain	0.0	0.0	0.0	0.0	0.3	1.1	0.3	0.2	0.0	0.0	0.0	0.0	0.1	0.1
Sweden	3.9		13.3		49.1		47.6		55.3		54.4		60.0	
Switzerland	0.9		1.0			57.4			72.9			91.1		
UK	1.6		3.0		25.5	26.9	31.4	31.4	45.2	52.1	47.7	49.4	48.2	
USA	4.5	4.9	4.9	5.7	41.2	40.9	41.0	42.9	43.7	44.2	45.3	45.5	46.7	47.3

Source: Cincera (1998).

Following Capron and Cincera (1998), four alternative specifications of Xit have been considered:

- **Specification I**: impact of the total stock of spillovers

$$\gamma \ln X_{it} = \gamma_T TS_{it} \qquad (2)$$

where: TS is the total stock of spillovers.

• **Specification II**: differentiated impact of the local and external stocks of spillovers

$$\gamma \ln X_{it} = \gamma_L \ln LS_{it} + \gamma_E \ln ES_{it} \tag{3}$$

where: LS, ES are the local and external stocks of spillovers respectively.

• **Specification III**: differentiated impact of the national and international spillover stocks

$$\gamma \ln X_{it} = \gamma_N \ln NS_{it} + \gamma_I \ln IS_{it} \tag{4}$$

where: NS, IS are the national and international spillover stocks respectively.

• **Specification IV**: totally differentiated impact of the spillover stocks

$$\gamma \ln X_{it} = \gamma_{LN} \ln LNS_{it} + \gamma_{LI} \ln LIS_{it} + \gamma_{EN} \ln ENS_{it} + \gamma_{EI} \ln EIS_{it} \tag{5}$$

where LNS, LIS, ENS, EIS are the local national, local international, external national and external international spillover stocks respectively.

Given these formulations, the estimated coefficients associated with the spillover components can be interpreted as elasticities of output with respect to these components.

2.3. Econometric framework

A standard approach to estimate these equations in the context of panel data, is to first-difference them to remove permanent unobserved heterogeneity and to use lagged levels of the series as instruments for the predetermined and endogenous variables in first-differences[4]. However, in relatively short panels with highly persistent data, this standard GMM estimator has been found to have large finite sample bias and poor precision in simulation studies[5]. The main contribution of this study is to compare the results of Capron and Cincera (1998) with the ones based on a system GMM estimator that relies on relatively mild restrictions on the initial condition process. Arellano and Bover (1995) and Blundell and Bond (1998) show that mean stationarity in an AR(1) panel data model is sufficient to justify the use of lagged differences of the dependent variable as instruments for equations in levels, in addition to lagged variables in levels as instruments for equations in first-differences. This result naturally extends to models with weakly exogenous covariates. Given the restriction on the initial conditions, the system GMM estimator is also shown to encompass the GMM estimator based on the non-linear moment conditions available in the dynamic error components model (Ahn and Schmidt, 1995). The system GMM estimator has substantial asymptotic efficiency gains with respect to the non-linear GMM estimator, and these advantages are reflected in the finite sample properties. In particular, both a large bias and very low precision for the standard first-differenced estimator are found when the individual series are highly persistent. By exploiting instruments available for the equations in levels, the system GMM estimator can both greatly improve the precision and greatly reduce the finite sample bias when these additional moment conditions are valid. Intermediate results for the non-linear GMM estimator

[4] See Anderson and Hsiao (1981), Holtz-Eeakin, Newey and Rosen (1988) and Arellano and Bond (1991).
[5] See the experimental evidence and the theoretical discussions in Ahn and Schmidt (1995) and Alonso-Borrego and Arellano (1999).

suggest that this estimator could also be useful in applications with persistent series where the validity of the initial conditions restrictions required for the system GMM estimator are rejected.

3. EMPIRICAL RESULTS

Estimation results of the productivity equations based on different components of the R&D spillover stock are given in Table 3.1. Table 3.2 reports the results by geographic area, i.e. EU, Japan and the US, by considering the total R&D spillover pool split into its domestic and international components.

Table 3.1. Impact of R&D spillovers on productivity: local, domestic vs. external, international components

DEPENDENT VARIABLE LN S									SAMPLE: 625 FIRMS X 8 YEARS		
Within level			OLS F.D.			GMM-IV F.D.			SYSTEM GMM		
ln L	0.50*	(0.160)	Δln L	0.40*	(0.029)	Δln L	0.56*	(0.059)	Δln L	0.56*	(0.087)
ln C	0.21	(0.130)	Δln C	0.17*	(0.022)	Δln C	0.22*	(0.047)	Δln C	0.08	(0.059)
ln K	0.24*	(0.015)	Δln K	0.32*	(0.043)	Δln K	0.11*	(0.031)	Δln K	0.19*	(0.043)
ln TS	1.11*	(0.151)	Δln TS	0.94*	(0.277)	Δln TS	0.73*	(0.226)	Δln TS	0.25*	(0.098)
R^2	0.993		R^2	0.358		X^2 (d.f.)	176.90	(108)	X^2 (d.f.)	142.09	(100)
ln L	0.50*	(0.016)	Δln L	0.41*	(0.029)	Δln L	0.56*	(0.085)	Δln L	0.61*	(0.071)
ln C	0.22*	(0.013)	Δln C	0.17*	(0.022)	Δln C	0.30*	(0.085)	Δln C	0.19*	(0.064)
ln K	0.25*	(0.015)	Δln K	0.33*	(0.042)	Δln K	0.14*	(0.060)	Δln K	0.20*	(0.045)
ln NS	-0.31*	(0.050)	Δln NS	-0.19**	(0.106)	Δln NS	-0.31	(0.198)	Δln NS	-0.81*	(0.149)
ln IS	1.03*	(0.122)	Δln IS	0.65*	(0.209)	Δln IS	2.10*	(0.403)	Δln IS	1.13*	(0.165)
R^2	0.993		R^2	0.359		X^2 (d.f.)	136.20	(70)	X^2 (d.f.)	174.35	(95)
ln L	0.49*	(0.016)	Δln L	0.40*	(0.029)	Δln L	0.66*	(0.050)	Δln L	0.60*	(0.043)
ln C	0.21*	(0.013)	Δln C	0.17*	(0.022)	Δln C	0.17*	(0.042)	Δln C	0.20*	(0.034)
ln K	0.24*	(0.015)	Δln K	0.32*	(0.043)	Δln K	0.09*	(0.029)	Δln K	0.11*	(0.026)
ln LS	0.25*	(0.042)	Δln LS	0.24*	(0.067)	Δln LS	0.23*	(0.057)	Δln LS	0.19*	(0.043)
ln ES	0.59*	(0.125)	Δln ES	0.60*	(0.228)	Δln ES	0.34*	(0.167)	Δln ES	-0.03	(0.063)
R^2	0.993		R^2	0.359		X^2 (d.f.)	204.03	(135)	X^2 (d.f.)	238.42	(160)
ln L	0.50*	(0.016)	Δln L	0.41*	(0.029)	Δln L	0.71*	(0.070)	Δln L	0.78*	(0.059)
ln C	0.22*	(0.013)	Δln C	0.17*	(0.022)	Δln C	0.13*	(0.066)	Δln C	0.08	(0.053)
ln K	0.24*	(0.015)	Δln K	0.32*	(0.043)	Δln K	0.08**	(0.050)	Δln K	0.10*	(0.041)
ln LNS	-0.06*	(0.025)	Δln LNS	-0.01	(0.045)	Δln LNS	0.07	(0.079)	Δln LNS	-0.04	(0.056)
ln LIS	0.19*	(0.035)	Δln LIS	0.15*	(0.060)	Δln LIS	0.31*	(0.097)	Δln LIS	0.38*	(0.078)
ln ENS	-0.41*	(0.046)	Δln ENS	-0.26*	(0.096)	Δln ENS	-0.70*	(0.140)	Δln ENS	-0.94*	(0.115)
ln EIS	0.68*	(0.097)	Δln EIS	0.46*	(0.185)	Δln EIS	1.75*	(0.299)	Δln EIS	1.18*	(0.118)
R^2	0.993		R^2	0.359		X^2 (d.f.)	181.19	(98)	X^2 (d.f.)	280.5	(175)

Notes:

*(**) =statistically significant at the 5 (10)% level;

Heterosckedastic-consistent standard errors in brackets;

Instruments used: observations dated t-1,t-2,t-3,t-4,t-5,t-6,t-7 in GMM FD and t-2,t-3,t-4,t-5,t-6,t-7 in system GMM for total stock of spillovers; t-3,t-4,t-5,t-6,t-7 in GMM FD and system GMM for national/international stock of spillovers; t-1,t-2,t-3,t-4,t-5,t-6,t-7 in GMM FD and system GMM for local/external stock of spillovers; t-3,t-4,t-5,t-6,t-7 in GMM FD and system GMM for local national and local international/external national and external international stock of spillovers.

X^2 (d.f.) Sargan overidentification test (Sargan test) and number of degrees of freedom in brackets.

It follows from Table 3.1 that the estimates associated with the elasticities of output with respect to the physical capital and labour are similar among estimation procedures: about 0.2 for the physical capital and 0.5 for labour. As far as the R&D stock is concerned, the introduction of lagged values of regressors as instruments reduces the coefficients from 0.2-0.3 for the within and OLS F.D. estimators to 0.11 for GMM F.D. and 0.19 for system GMM. The elasticity of output with respect to the total stock of spillovers is similar for within, OLS F.D., GMM F.D., that is around 1, but for system GMM the coefficient is much weaker (about 0.25). Given that this last estimator is more precise compared to the other ones, we could explain this result by the existence of single components of spillovers which have negative effect on output and thus reduce the effect of total spillovers. In fact, if we consider the effects on output of single components of spillovers, we can see that some of these variables have a negative coefficient. National spillovers have in general a negative coefficient while international ones have a positive coefficient[6]. In this case, we note that the standard errors of system GMM estimators are smaller than the ones corresponding to the other estimators. Finally, external spillovers have higher effects than local ones (only for system GMM estimates external stock coefficient is not significative).

Table 3.2. Impact of R&D spillover on productivity: domestic vs. international components

DEPENDENT VARIABLE LN S											
Within level			OLS F.D.			GMM F.D.			SYSTEM GMM		
US sample 3024 (2646 obs.)											
lnL	0.66*	(0.030)	Δ lnL	0.47*	(0.031)	Δ lnL	0.63*	(0.011)	Δ lnL	0.63*	(0.010)
lnC	0.11*	(0.027)	Δ lnC	0.13*	(0.025)	Δ lnC	0.10*	(0.008)	Δ lnC	0.11*	(0.007)
lnK	0.18*	(0.024)	Δ lnK	0.28*	(0.039)	Δ lnK	0.18*	(0.011)	Δ lnK	0.18*	(0.009)
lnNS	0.69*	(0.179)	Δ lnNS	0.59*	(0.202)	Δ lnNS	0.59*	(0.071)	Δ lnNS	0.45*	(0.043)
lnIS	-0.02	(0.155)	Δ lnIS	-0.43	(0.273)	Δ lnIS	-0.10	(0.110)	Δ lnIS	-0.40*	(0.044)
R^2	0.995		R^2	0.468		X^2(d.f.)	245.53	(200)	X^2(d.f.)	258.30	(225)
JP sample 1064 (931) obs.											
lnL	0.23*	(0.053)	Δ lnL	0.11*	(0.040)	Δ lnL	0.32*	(0.036)	Δ lnL	0.30*	(0.030)
lnC	0.28*	(0.033)	Δ lnC	0.18*	(0.035)	Δ lnC	0.21*	(0.016)	Δ lnC	0.16*	(0.021)
lnK	0.07*	(0.040)	Δ lnK	0.28*	(0.011)	Δ lnK	-0.04*	(0.016)	Δ lnK	-0.04**	(0.022)
lnNS	-0.17	(0.149)	Δ lnNS	-0.23	(0.403)	Δ lnNS	-0.26*	(0.077)	Δ lnNS	-0.53*	(0.079)
lnIS	0.91*	(0.307)	Δ lnIS	1.46*	(0.621)	Δ lnIS	1.49*	(0.142)	Δ lnIS	1.62*	(0.118)
R^2	0.992		R^2	0.221		X^2(d.f.)	108.21	(100)	X^2(d.f.)	117.13	(95)
EU sample 808 (707) obs.											
lnL	0.63*	(0.052)	Δ lnL	0.53*	(0.066)	Δ lnL	0.51*	(0.026)	Δ lnL	0.55*	(0.036)
lnC	0.18*	(0.035)	Δ lnC	0.09	(0.066)	Δ lnC	0.22*	(0.012)	Δ lnC	0.21*	(0.020)
lnK	0.04	(0.053)	Δ lnK	0.22*	(0.105)	Δ lnK	0.00	(0.012)	Δ lnK	-0.16*	(0.028)
lnNS	0.13	(0.140)	Δ lnNS	0.13	(0.281)	Δ lnNS	0.04	(0.026)	Δ lnNS	0.01	(0.059)
lnIS	0.32	(0.269)	Δ lnIS	0.06	(0.565)	Δ lnIS	0.41*	(0.103)	Δ lnIS	0.83*	(0.083)
R^2	0.996		R^2	0.417		X^2(d.f.)	91.76	(85)	X^2(d.f.)	85.08	(75)

Notes:
*(**) =statistically significant at the 5 (10)% level;
Heterosckedastic-consistent standard errors in brackets;
Instruments used: observations dated t+1,t,t-1,t-2, t-3, t-4, t-5,t-6 and t-7 for USA for both GMM FD and system GMM; t-2,t-3, t-4,t-5,t-6, and t-7 for Japan GMM FD; t-3,t-4,t-5,t-6,t-7 for Japan system GMM; t-1,t-2,t-3 for Europe GMM FD and t-2,t-3 for Europe system GMM.
X^2 (d.f.) Sargan overidentification test (Sargan test) and number of degrees of freedom in brackets.

[6] As emphasised by Mohnen (1996), R&D of rivals can have detrimental effects on profit or productivity growth of firms competing in the same market.

This result seems to indicate that the inter-industry spillover effects on productivity performance are relatively more important than the intra-industry ones, as far as we consider that there is a close relationship between industries and technological classes. It should also be noted that some results might be affected by multicollinearity problems among the different stocks and that for some specifications, the instrument set has been rejected by the Sargan test.

In Table 3.2, we take directly into account the geographic dimension of the data set. Results of the effects of national and international stocks of R&D spillovers on output are performed for the US, Japan and Europe separately. We can observe that the US firms benefit principally from their national stock of spillovers, while Japan is more sensitive towards international ones. These facts are clear for all econometric models. In the case of Europe, only the GMM estimates appear to be significant, with a positive effect for the international spillover stock.

Table 3.3. Domestic vs. International spillover effects: Comparison with Capron and Cincera (1998).

DEPENDENT VARIABLE LN S					
GMM F.D. Capron and Cincera (1998)			SYSTEM GMM this paper		
US sample 3024 (2646) obs.					
Δ lnL	0.51*	(0.012)	Δ lnL	0.63*	(0.010)
Δ lnC	0.10*	(0.001)	Δ lnC	0.11*	(0.007)
Δ lnK	0.25*	(0.013)	Δ lnK	0.18*	(0.009)
Δ lnNS	0.56*	(0.075)	Δ lnNS	0.45*	(0.043)
Δ lnIS	-0.35*	(0.122)	Δ lnIS	-0.40*	(0.044)
X²(d.f.)	239.8	(195)	X²(d.f.)	258.30	(225)
JP sample 1064 (931) obs.					
Δ lnL	0.09*	(0.001)	Δ lnL	0.30*	(0.030)
Δ lnC	0.12*	(0.001)	Δ lnC	0.16*	(0.021)
Δ lnK	0.10*	(0.001)	Δ lnK	-0.04	(0.022)
Δ lnNS	0.28*	(0.028)	Δ lnNS	-0.53*	(0.079)
Δ lnIS	0.97*	(0.065)	Δ lnIS	1.62*	(0.118)
X²(d.f.)	123.0	(120)	X²(d.f.)	117.13	(95)
EU sample 808 (707) obs.					
Δ lnL	0.56*	(0.001)	Δ lnL	0.55*	(0.036)
Δ lnC	0.11*	(0.001)	Δ lnC	0.21*	(0.020)
Δ lnK	0.15*	(0.001)	Δ lnK	-0.16*	(0.028)
Δ lnNS	0.12*	(0.032)	Δ lnNS	0.01	(0.059)
Δ lnIS	-0.12*	(0.030)	Δ lnIS	0.83*	(0.083)
X²(d.f.)	97.4	(95)	X²(d.f.)	85.08	(75)

Notes:
*(**) =statistically significant at the 5 (10)% level;
Heterosckedastic-consistent standard errors in brackets;
Instruments used: observations dated t+1,t,t-1,t-2, t-3, t-4, t-5,t-6 and t-7 for USA (GMM FD and system GMM); t-2,t-3,t-4,t-5,t-6, and t-7 for Japan GMM FD; t-3,t-4,t-5,t-6,t-7 for Japan system GMM; t-1,t-2,t-3 for Europe GMM FD and t-2,t-3 for Europe system GMM.
X² (d.f.) Sargan overidentification test (Sargan test) and number of degrees of freedom in brackets

To complete the analysis, we compare the results of Capron and Cincera (1998) as regards the national and international stocks of spillovers for different geographic areas with the ones obtained in this paper. Since the results for the OLS F.D. and within estimators are roughly the same, we only report and compare the results for the GMM F.D. estimator. The most important difference concerns the results for Europe[7]. In this case, the improvement of efficiency due to the system GMM estimator leads to a remarkable result: Europe is more sensitive to the international spillover stock which appears to positively affect the productivity performance of firms operating in that continent.

4. CONCLUSIONS

In this paper we consider the effects of national and international stocks of spillovers on the productivity growth of large international R&D firms. Given the panel data structure of the sample, these effects are estimated by means of system-GMM and compared with the findings of Capron and Cincera (1998). First, basic results on the relationship between firms' output and the total pool of spillovers and its different components, i.e. local, external, national and international, are discussed. Second, the differentiated importance of domestic and international spillover effects across firms of different geographic areas is also explored. The main empirical findings in general suggest a positive impact of technological spillover on firms productivity. Moreover, when the geographic dimension is taken into account, we observe that US companies for the most part benefit from their national R&D spillover stock, while firms in Japan and Europe appear to mainly draw from the international stock. This work could be extended by updating the data set to the more recent period, by investigating alternative technological (and geographic) proximity measures to construct the spillovers components and by examining more precisely the time it takes to R&D spillovers effects to show up on productivity growth.

[7] Another source of difference comes from the chosen set of instruments.

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